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ONE OF THE REASONS FOR THE ASYMMETRY OF THE LUNAR SHAPE

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ONE OF THE REASONS FOR THE ASYMMETRY OF THE LUNAR SHAPE

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ABSTRACT. The photography of the other side of the Moon, which was first performed by the Soviet Automatic Interplanetary Station "Luna-3" reveals the great difference between the shape of the visible side of the Moon and the side turned away from us. The reason for this difference is still a puzzle to us. However, it may be assumed that the asymmetrical form results from the prolonged structural development of the natural satellite of the Earth. There will probably be many explanations for this. In this article, the author proposes dissimilar conditions for volcanic activity on the visible and reverse sides of the Moon. This explanation is promising. However, it must be kept im mind that the author has developed a concept about the mechanism for the action of volcanos which cannot be unconditionally assumed either for the Earth or for the Moon. The editors hope that this article will provoke some discussion.

We now know that the lunar seas are primarily located on the visible side /90* of the Moon, and are almost completely absent on the other side of the Moon. Therefore, it is worthwhile to direct our attention only to the concept for the origin of cirques, craters, and other features, of the lunar releif which may explain the asymmetry of the Moon.

Existing hypotheses regarding the origin of the Moon explain the nature of its shape either by intense tectonic processes which to lead to subsequent collapse of sections of the lunar surface, or by the impacts of enormous

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* Numbers in margin indicate pagination in the original foreign text.

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meteorites, comets, or planetisimals which lead to vaporization and dispersion of the lunar surface, with subsequent erruption of lava from the depths of the Moon.

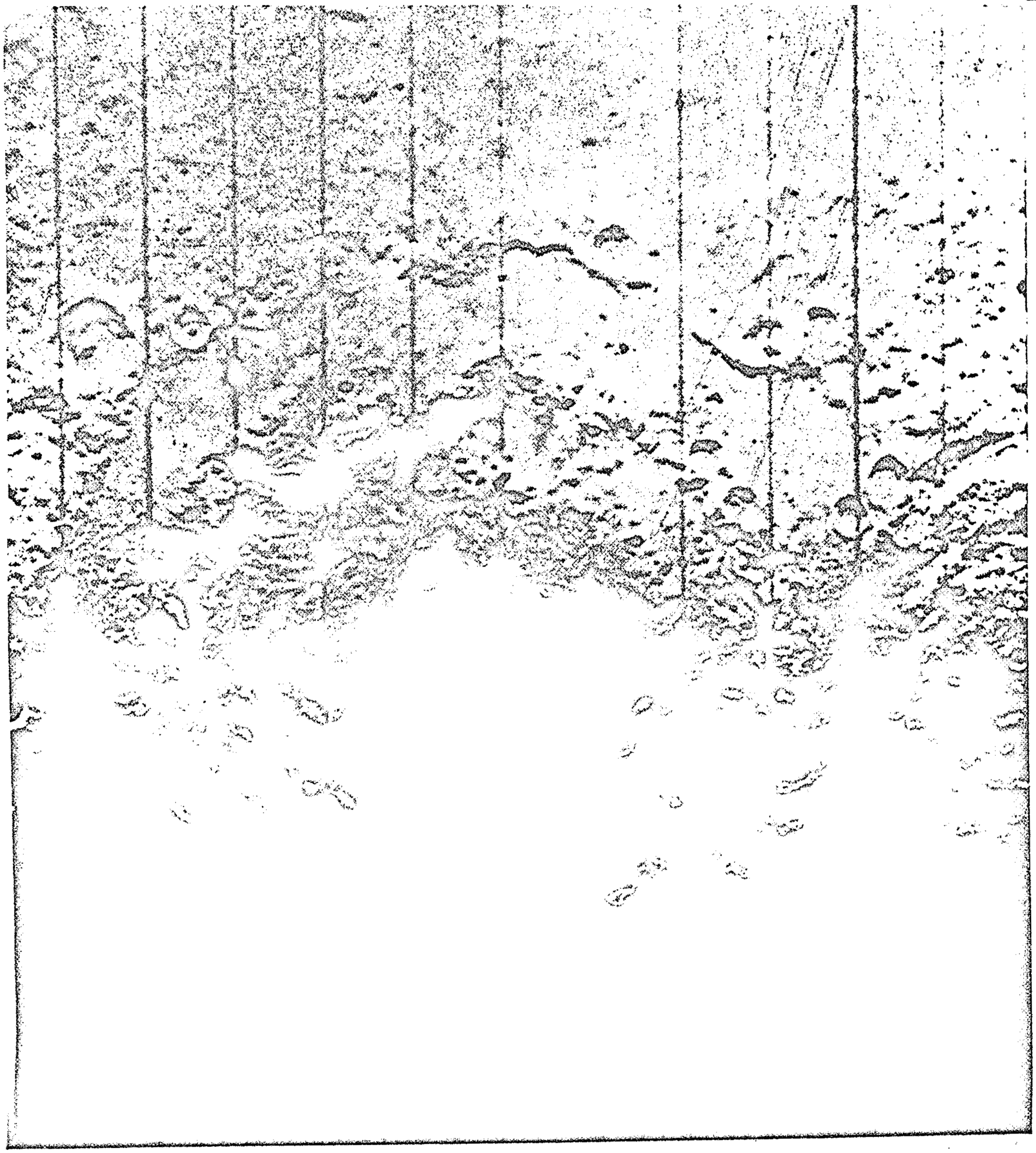
The problem of why one side of Moon is constantly turned towards the Earth has still been far from clarified. It is usually assumed that the lunar rate of rotations around its axis was previously larger, and that the Moon was closer to the Earth. Consequently, the orbital period of the Moon around the Earth was shorter.[2] One indisputable reason for the constantly visible side of the Moon is that a tidal wave slowed down its rotation, which was produced by the attraction of the Moon by the Earth and the Sun. The increase in the lunar period of rotation, caused by this tidal wave, and also the increase in the lunar orbital period must have led to their similar duration, i.e., to a side of the Moon constantly turned toward the Earth. However, there is no explicit and uniform connection between the causes of seas on the lunar surface, and the causes of a change in the rotation rate and orbital rate of the Moon.

Large cosmic bodies which can produce about 20 enormous seas impacting on the Moon can influence the rate of rotation of the Moon and its orbital period. However, in order to stipulate that the similarity between the rotational periods and the orbital periods of the Moon is only result of the occurence of seas, we must completely exclude the case of 15 - 20 cosmic bodies (such as planetisimals or comets)impacting on the same side of the Moon. These bodies would form seas and would slow the rotation of the Moon to the extent that its period of rotation would coincide with the orbital period. This is very improbable.

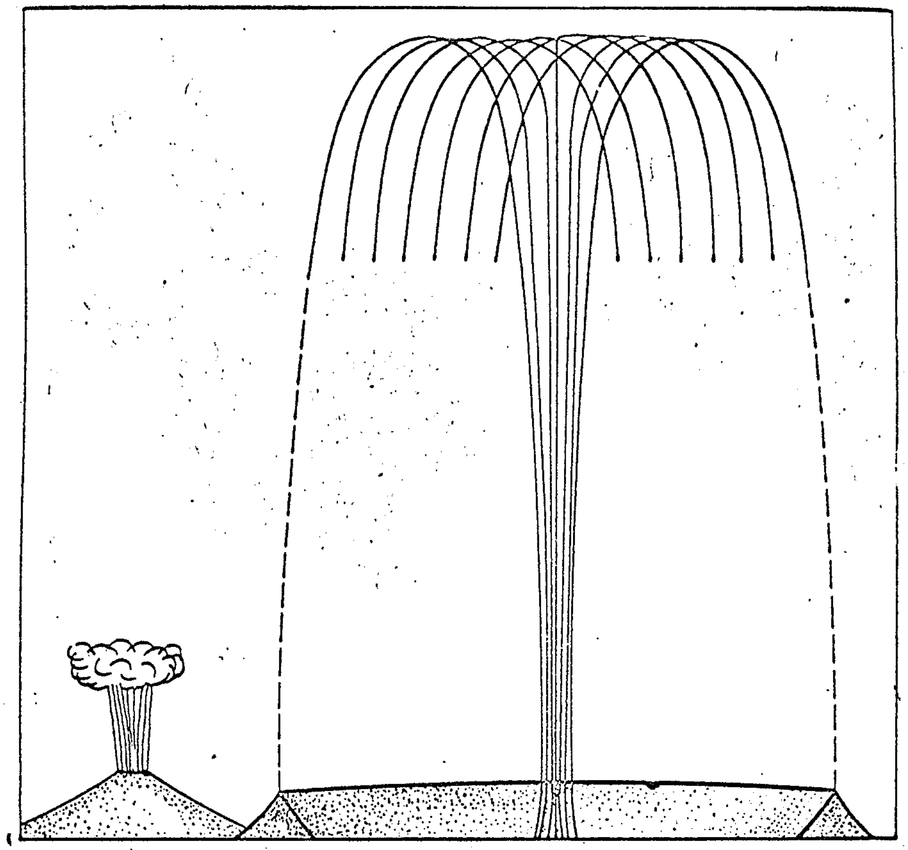
It is more valid to assume that the lunar seas were formed at its origin, namely,that the side where they are located was always turned toward the Earth. In this case, the cause of the constantly visible side of the Moon is a natural one, and a result of tidal deceleration. The period of time that the visible

[2] Priroda, No. 4, 1968, pp. 24-38.

and nonvisible sides have been in existence will only be the essential and important feature in the formation of a variety of structural elements on the visible side. Different elements on the moon were formed over a long period /92



Photograph of the "Eastern" Basin discovered on the other side of the Moon.



Comparative dimensions of the height and diameter of the volcanic eruptions under conditions on the Earth (left) and on the Moon (right).

of time[3]. However, this is incompatible with the hypothesis of their meteorite origin only on the visible side. The Moon makes one revolution every ~ 27 days and the impact of meteorites on same side of even a slowly rotating Moon is very improbable. If we assume that the seas are due to volcanic eruptions or other phenomena leading to a change in the chemical composition and physical properties of rocks comprising the crust of the Moon, then there is no contradiction in the occurrence of such processes only on the visible side in principle. In this case, the question is only whether there are, on the visible side of the Moon, features which are necessary and sufficient to produce the predominant occurrence of seas, cirques, and craters as a result of

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(3) The differing degree of preservation indicates this (A. V. Khabakov, 1949).

volcanic activity. Two important features of the visible side of the Moon must be noted.

One of these features is that the visible side throughout the Lunar night (13 terrestrial days) is illuminated by the Earth, which illuminates the Lunar sky in the same way that about 80 Moons would illuminate the Earth's sky. This feature produces much more favorable conditions for the occurrence and existence of the simplest form of life on the Moon. The question of microbiological life or traces of it on the Moon is not solved, but if they do exist , we must then recall the words of the Soviet scientist V. I. Vernadskiy, who wrote: "The entire existence of the Earth's crust, at least 99% of its mass by weight, depends on life processes, in terms of its features which are important from the geochemical point of view".

The second feature of the visible side of the Moon is clearer. This consists of the fact that the Earth's attraction is always directed only twoard the visible side, decreasing the attractive force on it. This decrease is most noticable at perigee, when the distance to the Moon is the least, and also during the full Moon, when the attraction of the Earth and the Sun act concurrently. The English astronomer Kopal (1963) has called attention to the difference in the total gravitation and the critical escape velocity of gas molecules lost by the Moon, which is dependent on this.

In investigating the problem of the dependence of the critical velocities at which gas molecules leave the Moon, on the position of the Moon with respect to the Earth and the Sun, Kopal showed that the critical velocity V_k, which must equal $V_k = \sqrt{2gR}$ without allowance for the influence of centifigal force and attraction of the Earth and the Sun, is $\simeq$ 2380 m/sec (for a radius of R = 1738 km and g = 1.62 m/sec^2). Kopal assumed that the closeness of the Earth and the similar direction of the forces of attraction of the Sun and the Earth during the full Moon decreased the critical velocity to 2204 m/sec. /93

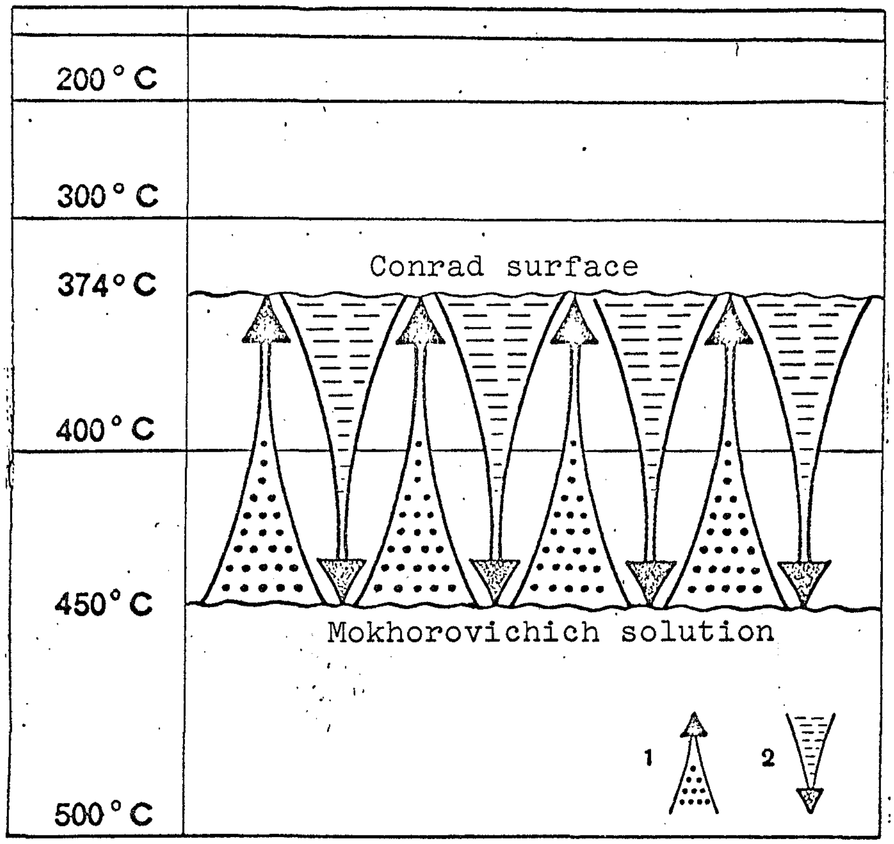

Diagram for the formation of a drainage mantle: 1 - ascending motion of water vapor from the isothermal surface of water (374°C); 2 - decending motion of liquid water solutions from the isothermal surface of water (374°C) to the isothermal surface of water solutions (450°C).

"Consequently", writes Kopal, "changes in the critical velocity may be extimated, but the results (if they exist in general) of said changes are still unknown".(4)

In discussing these very important differences in the critical velocity, this scientist did not note that they are characteristic for different sides of the Moon, because the terrestrial gravitation always decreases the force of gravity on the visible side, and increases it on the opposite side. The solar gravity acting concurrently with the terrestrial gravity only during the full Moon phase, also decreases the force of gravity on the Moon on the visible side. In our opinion, this distinctive feature of the visible

(4) Z. Kopal, The Moon, Foreign Literature Pulishing House, 1963, p. 14.

side of the Moon may be used to explain the asymmetry of the lunar shape.

It is usually assumed that Volcanism is connected with lava rising from the depths or with the change of solid rocks to a liquid state due to a pressure decrease. It may naturally be expected that, if there is a decrease in the force of gravity on the visible side of the Moon, discharge of gases and lava on the visible side are more probable. However, the simple discharge of melted lava cannot explain the formation of cirques having a diameter greater than 200 km in the case of a very low cirque elevation.

In my opinion, the cause of volcanic activity may be found in the formation of high temperature solutions of mineral substances in the depths of the lunar crust. The solutions of mineral substances are formed due to a constant vertical circulation of water, which rises in a supercritical vaporous state from the interior to the isothermal surface of its critical state (374.15°C). The vapors condence here, and form liquid solutions of mineral substances. Since these solutions have higher critical temperatures, they descend to the isotherm ~ 450°C, where, changing into vapor, they leave the mineral substances dissolved in them, cementing and solidifying the rocks of the lower layers. As a result of prolonged and constant circulation of water, there must be an abrupt change in the chemical and mineralogical composition and physical properties of the rocks.

Under the conditions of the Earth's crust, a sharp change is produced in the same way, which is called the Mokhorovichich Divide. As a result of vertical circulation, a second characteristic boundary is also produced — the Conrad Boundary, above which the rocks in the Earth's crust are rich in silica and radioactive substances. The occurrence of this boundary may be explained by the fact that silica, which is volatile with vapor, separates out of the 374°C isotherm, where water vapor condenses. The layers of rocks lying between these two mantles becomes more fractured, porous, and permeable due to the constant vertical circulation of water solutions. This mantle may be called /94
a drainage mantle, because its permeability makes possible horizontal displacments of solutions from sections of the crust with increased hydrostatic

pressure where the pressure is lower. The lower boundary of this mantle under the continents lies at a depth of 37 km, and above the oceans — at a depth of 7 km. Under the conditions on the Moon, such a mantle must also exist with a temperature of 374 - 450°C. It has recently been assumed that these temperatures may be encountered in the depths of the Mocn at a depth which is 5-6 times greater than in the depths of the Earth. However, measurements performed at the Scientific Research Radiophysical Institute under the leadership of V. S. Troitskiy left no doubt that there are temperature conditions in the crust of the Moon which are close to those existing in the depths of the Earth. Based on these measureemnts, in the depths of the Moon the temperature is 1000°C at a depth of 50 km. The thermal flux of the Moon equals that of the Earth. This means that the lower boundary of the drainage mantle in the crust of the Moon may lie at about 25 km, whereas the upper mantle may lie (t = 374°C) at a depth of ~15 km.

The presence of the mantle, whose complex system of cavities is filled with supercritical vapors and liquid solutions of mineral substances (with a critical temperature between 374 - 450°C and a critical pressure of 225 atm) for pure water) may fully explain the intense volcanic activity, whose traces are so diverse on the Lunar surface. Each outburst of hot solutions thruogh the lunar crust will lead to erruption of water vapors and solutions. From the latter,mineral substances contained in the solutions will fall on the lunar surface in the form of ashes due to a sharp reduction in temperature and pressure. Craters and cirques will thus be formed. However, in order that the vapors may emerge from the depths, they must overcome the resistance of liquid solutions which fill the systems of cracks combining the drainage mantle with the Lunar surface. The hydrostatic pressure of a column of liquid, 15 km high, equals 1.5 thousand atmospheres under conditions of the Earth's crust. It comprises 250 atmospheres in the Lunar crust, i.e., it is 6 times less. Therefore, volcanic eruptions, i.e., eruptions of vapors, gases, and mineral substances dissolved in them, can take place during the formation of any system of cracks leading to the drainage mantle. Each reduction in the weight of the column of liquid blocking the outflow of vapors to the surface must contribute to the outburst of solutions from the drainage mantle.

Therefore, volcanic activity must be more intense on the visible side of the Moon. During the full Moon, the weight of the liquid column decreases, and becomes surmountable for a pressure of 225 atmospheres produced by water at a critical temperature.

When comparing the dimensions of craters formed during volcanic eruptions on the Earth and the Moon, where enormous cirques are located, we must conclude that attraction on the Moon is six times less than on the Earth, and that there is no atmosphere on the Moon. Both of these factors can contribute to the ejection of a large amount of material from Lunar craters and to the great height of these ejections.

In order to explain the volcanic eruptions which can form particularly large cirques or even lunar seas, the drainage mantle must have a permeability such that constantly new masses of solutions enter the mouth of the volcano during the eruption. In addition, the "simultaneous" action of many volcanos on a section of the ensuing sea is necessary. Since the force of gravity decreases significantly primarily on the visible side of the Moon, it is natural to conclude that the predominant formation of seas is possible on the visible side due to the "simultaneous" eruption of many volcanos . In contrast to this, on the far side of the Moon, where the gravity is always greater than on the visible side, volcanic activity may take place much less frequently. Since volcanic eruptions are only possible at high pressures, making it possible to overcome high resistance, these eruptions must be more intense. Therefore, the average size of craters and the maximum diameters of cirques on the other side of the Moon may be much greater than on the visible side.

This hypothesis is confirmed, for example, by a composite cirque shown on one of the photographs taken by the satellite "Lunar Orbiter - IV" on May 5, 1967. It consists of 3 - 4 cirques arranged concentrically, whose diameters range between 400 - 1000 km. Based on the sharpness and distinctness of elements of the cirques, the mountain ridges, canyons, and hollows of this immense basin, it is apparent that it was formed recently and has barely been erroded. It was apparently formed due to several consecutive, enormous eruptions of one and the same crater.

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